WHAT DO WE KNOW ABOUT KNOWLEDGE INTEGRATION: FUSING MICRO AND MACRO ORGANIZATIONAL PERSPECTIVES

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ABSTRACT

Knowledge integration is the *raison d'etre* for the existence of the firm (Grant, 1996a, Kogut & Zander, 1992) and has been widely studied across many subfields in management and organizational studies. However, few constructs have received as much scholarly attention as knowledge integration while remaining so equivocally defined and measured, leading to a confusing array of conceptualizations, undermining its theoretical, empirical and practical usefulness. As a theoretical construct, knowledge integration also cuts across the macro and micro levels, gaining attention from scholars interested in explaining the microfoundations of strategy and capabilities (e.g., Felin & Hesterley, 2007; Lewin, Massini & Peeters, 2011). However, the interplay among these micro and micro factors is often overlooked and its implications for theory building is ignored.

To address these issues, we examine and integrate micro and macro organizational perspectives on knowledge integration. We provide a review of its definitions, and offer our definition based on key dimensions identified. We discuss and analyze the micro and macro perspectives, presenting key assertions, propositions, limitations, and conclusions from representative studies. Finally, we integrate the diverse perspectives we discuss, showing how their interplay can enrich future scholarship and our understanding of knowledge integration as a key organizational construct.

WHAT DO WE KNOW ABOUT KNOWLEDGE INTEGRATION: FUSING MICRO AND MACRO ORGANIZATIONAL PERSPECTIVES

Knowledge integration is central to the concept of the firm (Kogut & Zander, 1992). As a result, it has been studied across a wide array of the subfields of organizational studies. These studies have adapted diverse theoretical perspectives that include: the knowledge-based (Grant, 1996a, 1996b; Szulanski, 1996), resource-based or resource orchestration (Sirmon, Hitt, Ireland & Gilbert, 2010; Zahra & Nielsen, 2002), and relational views (Dyer & Singh, 1998), as well as the dynamic capabilities (Eisenhardt & Martin; 2000; Teece, 2007; Zahra & George 2002b) and absorptive capacity (Zahra & George, 2002a) perspectives. Knowledge integration is also a key construct in studies seeking to explain the emergence of combinative capabilities (Kogut & Zander, 1992) that lead to innovation (Agarwal, Audretsch & Sarkar, 2010), the mainspring of organizational adaptation. In studying knowledge integration, researchers have explored organizational outcomes as diverse as new product development speed, productivity and quality (Iansiti & West, 1997), firm growth (Lorenzoni & Liparini 1999), sustainable competitive advantage (Grant, 1996a, 1996b), ex-ante value gains from alliances (Liu & Ravichandran, 2015), alliance ambidexterity (Tiwana, 2008), team performance (Robert, Dennis & Ahuja, 2008), product diversification (Alcalde Heras, 2014), and knowledge co-creation (Majchrzak, More & Faraj, 2012). As such, some believe knowledge integration is at the heart of the concept of the firm (Kogut & Zander, 1992).

As a theoretical construct, knowledge integration also cuts across the macro and micro levels, with much recent attention on knowledge transactions and processes at the individual level from scholars interested in explaining the microfoundations of strategy and capabilities (e.g., Felin & Hesterley, 2007; Felin, Foss, & Ployhart, 2015; Lewin, Massini & Peeters, 2011). However, the interplay among these micro and micro factors is often overlooked and its implications for theory building is ignored. Thus, few constructs have received as much scholarly attention as knowledge integration while remaining so equivocally defined, leading to a confusing array of conceptualizations. Attempts to measure or empirically capture the construct have been as equally diverse, undermining its theoretical, empirical, and practical usefulness.

To address these issues, we examine and integrate micro and macro perspectives on knowledge integration in organizations and show how the integration of these perspectives can enrich future research and theory building. Given the diverse definitions of knowledge and knowledge integration that exist, we provide a review of these definitions, and offer our definition of the later based on key dimensions identified in the literature. Next, we discuss and analyze the micro perspectives on knowledge integration, focusing on individual and group level memory (i.e., transactive memory systems and routines), and macro-level perspectives (i.e., organizational boundaries perspective, capabilities perspective, knowledge management perspective, knowledge based view, and organizational learning perspective). For each of these perspectives, we discuss key assertions, propositions, and conclusions from representative studies. We also summarize the

key takeaways from each perspective and identify their critical shortcomings. Finally, we integrate the diverse micro and macro perspectives we discussed, showing how their interplay can enrich future scholarship and our understanding of knowledge integration as a key organizational construct.

WHAT IS KNOWLEDGE?

We believe a key impediment to understanding the nature, role, and consequences of knowledge integration in organizations is the lack of precision about knowledge and knowledge integration. To gain better insights, we reviewed the literature at the individual, group, and organizational levels. Surprisingly, explicit definitions were extremely scarce as very few authors offered a definition of knowledge itself. While we had expected to see a more clearly explicated approach to defining knowledge when reviewing the individual level research, we found that even here, knowledge is treated as something that is operated on and represented in the contents of memory systems, not requiring explicit definition (e.g., Baddeley, 2002; Feldman et al., 2004).

Grant's (1996a, 110) seminal paper addresses the issue of definition head-on, stating that:

> "Developing a knowledge-based theory of the firm raises the issue: What is knowledge? Since this question has intrigued some of the world's greatest thinkers from Plato to Popper without the emergence of a clear consensus, this is not an arena in which I choose to compete. In terms of defining knowledge, all I offer beyond the simple tautology of 'that which is known' is the recognition that there are many types of knowledge relevant to the firm.'"

Grant goes on to discuss knowledge in terms of declarative (i.e., know-that) and procedural (i.e., know-how) knowledge, which he further connects with explicit and tacit knowledge, respectively. He also points out that for his knowledge-based view, which centers on knowledge integration, the "critical distinction between the two lies in transferability and the mechanisms for transfer across individuals, across space, and across time." For Grant (1996a; 1996b) knowledge

varies in terms of its transferability, aggregability, and appropriability, which are captured by the notion of the tacitness of knowledge, which are shorthands for transferability and appropriability.

Kogut and Zander (1992) suggest that "the knowledge of the firm, as opposed to its learning, is relatively observable; operating rules, manufacturing technologies, and customer data banks are tangible representations of this knowledge" (384). Like Grant (2006a), Kogut and Zander (1992) categorize knowledge as information (i.e., declarative knowledge) and know-how (i.e., procedural knowledge), with information being "knowledge which can be transmitted without loss of integrity once the syntactical rules required for deciphering it are known. Information includes facts, axiomatic propositions, and symbols" (1992, 386). Kogut and Zander also point out that procedural knowledge or know-how, is a frequently used, but rarely defined, term. As with Grant (1996), Kogut and Zander identify codifiability and complexity as two dimensions of knowledge which are associated with its imitability and transferability.

Still at the organizational level, but in a different vein, Henderson and Clark (1990) distinguish between component and architectural knowledge. Component knowledge is knowledge "about each of the core design concepts and the way in which they are implemented in a particular component", while architectural knowledge is "knowledge about the ways in which the components are integrated and linked together in a coherent whole" (1990, 11). Helfat and Raubitschek (2000, 963) divide knowledge into similar types, that being core knowledge (i.e., defined as "at the heart of, and forms the foundation for, a particular service") and integrative knowledge (i.e., "knowledge that integrates, or knowledge of how to integrate, different activities, capabilities, and products in one or more vertical chains"). Such definitions further perpetuate the tautological nature of the field.

Several researchers take a more pragmatic, functionalist approach when defining knowledge, focusing on what the organization can do with its knowledge. For instance, Von Hippel (1998, 1988) suggests "know-how is the accumulated practical skill or expertise that allows one *to do something* smoothly and efficiently" (emphasis added). Similarly, Tsoukas and Vladimorou (2001, 981) define organizational knowledge as 'the set of collective understandings embedded in a firm, which enable it to *put its resources to particular uses*' (emphasis added). Taking a similar capabilities perspective, Leonard-Barton's (1992) claims that knowledge categories can be defined in terms of their nature within organizations. Although not defining knowledge itself, she does situate it, as it includes (a) employee's knowledge and skills, which are also embedded in (b) technical systems. This knowledge is the result of knowledge creation and control by (c) managerial systems, as well as (d) culture and values in the organization.

In research on transactive memory systems, we not only observe relatively few clear definitions of knowledge, but also find a reliance on the tacit-explicit categorization for understanding interpersonal knowledge transfer and aggregation (e.g., Akgün et al., 2006). However, Lewis et al. (2005) define integrated knowledge as that which is "encoded as shared higher-order information, defined as the 'topic, theme, or gist' of some set of lower-order information" (2005, 584).

Conceptualizations of Knowledge

Our review of existing definitions of knowledge enables us to offer four observations on how knowledge is defined or conceptualized in management and organizational studies, shaping views of knowledge integration.

Knowledge must be encoded and absorbed. First, knowledge that is integrated is re-encoded to combine key features or dimensions of the relevant knowledge structures, and then

absorbed into long term memory. This process is governed by an executive function in cognition which reflects attention to the knowledge. In the case of groups, or organizations, successfully integrated knowledge would also be shared or stored collectively in either group transactive memory, routines, or in the case of explicit knowledge, embedded in technologies or in management processes. Knowledge integration also depends upon attention, which is a capacity at the individual, group, and organizational levels.

Knowledge's form effects its transfer. Second, while knowledge has a number of characteristics relevant to transfer and appropriability, the principle characteristics effecting these processes are complexity and tacitness. Subsequent integration of knowledge may be hindered by these conditions.

Knowledge can be gained intentionally or unintentionally. Third, knowledge varies by the degree to which it is consciously acquired or created versus being heuristic and automatically or unconsciously created through experience. Since knowledge integration does not depend upon explicitness, heuristic and explicit knowledge may be integrated. However, since automatic knowledge creation is associated with tacitness, the extent to which knowledge creation and acquisition results in tacit knowledge would influence its integration at the group and organizational levels. Thus, mindful attention to knowledge creation and sharing will enhance integration, relative to reliance upon heuristic processing and tacit understanding.

Knowledge can be declarative or procedural. Fourth, knowledge and can be viewed as either representing component technologies or the architecture which connects those components. That is, knowledge may be declarative or procedural component knowledge, or declarative or procedural architectural knowledge. Since any of these forms of knowledge themselves may be

integrated with any other form, the significance is that these categories map onto systematic variations in complexity and tacitness.

DEFINING KNOWLEDGE INTEGRATION AND ITS DIMENSIONS

Even though knowledge itself was relatively infrequently defined in the literature, we found a multitude of widely varied definitions of knowledge integration, a realization which initially motivated us to conduct this integrative review. This diversity arises from different levels of analysis, outcomes researchers considered, the diversity of research streams which have examined knowledge integration, and the perceived or espoused role of knowledge integration in the explanation of individual, group, or organizational outcomes. Table 1 presents a sample of these definitions for illustration.

Insert Table 1 About Here

From our list of definitions, we distilled each down to its essential meanings, focusing of the key words and concepts, and removing extraneous words and phrases. This allowed us to identify the essential parts of each definition of the knowledge integration construct. From here, we identified six common dimensions of knowledge integration which appear in Figure 1. These dimensions are: 1) what is it (e.g., an ability, mechanism, or process); 2) who does it (e.g., companies, decision makers, or project committees); 3) what is done (e.g., absorbing, constructing, or encoding); 4) what is integrated (e.g., capabilities, component competencies, or technological or market capabilities); 5) what are the sources (e.g., alliance partners, customers, or past new product development project); and 6) what are the outcomes (e.g., explorative and exploitative

strategies, new meanings, and recombination of knowledge). Within each of these dimensions, we offer a few examples of the word and phrases associated with each dimension.

As shown in Figure 1, while there is general agreement on the dimensions of knowledge integration, the manner in which scholars conceptualize them varies widely. For example, there is some disagreement on exactly what knowledge integration is; some view it as a process (Marsh & Stock, 2003), routine (Zhou & Li, 2012), or reliable pattern (Gardner et al., 2012), while others see it as an ability or capability (e.g., Nonaka & Kenney, 1991). These differences have important implications for theorizing as the former definitions suggest that knowledge integration can be articulated and prescribed, while the latter suggests that knowledge integration is something to be developed or built. Figure 1 highlights the aforementioned lack of theoretical consistency, which has seriously hampered the development of the field. This divergence has limited the ability of the field to build upon prior work, or effectively draw inferences across studies.

Insert Figure 1 about Here

As we examined the existing definitions, most included several of these six common dimensions, yet very few captured all at once. Among the most comprehensive is the definition by Yeoh and Roth (1999) who forward that "integrative capabilities refer to the ability (what is it) of the firm (who does it) to use resources and component capabilities (what is integrated) to support organizational renewal (what are the outcomes). Drawing upon and synthesizing the commonalities and insights gained from Figure 1, we offer the following definition of knowledge integration:

> "Knowledge integration is an organizational capability for creating novel combinations of different strands of knowledge, which have utility for solving

> organizational problems, from component knowledge sourced from within and beyond the organization, and across time, and which derive from individual and group contributions, facilitated by both formal and social processes."

Now that we have presented definitions of knowledge and knowledge integration, our review will discuss and analyze the micro and macro level streams of research that have touched upon the knowledge integration process. For each major stream, we will present its key assertions and propositions, discuss the findings and conclusions from representative studies, identify the key takeaways from the body of research within the stream, and critique the stream of research by discussing its key shortcomings and limitations. To comprehend how the process of knowledge integration unfolds within a firm, it is essential to examine the contributions of individuals and groups, as we do next.

INDIVIDUAL LEVEL PERSPECTIVES ON KNOWLEDE INTEGRATION

Individual cognitions, skills, experiences, and aspirations can significantly influence information processes and knowledge integration. Thus, whatever integration of knowledge is achieved at one level is usually the outcome of several forces across other organizational levels. Moreover, the sharing and subsequent use of this knowledge by others introduces additional actors from other parts of the organization into the process. This suggests a need for a multilevel perspective when studying knowledge integration processes and their outcomes. Such an approach can be useful in understanding the socio-cognitive forces that unfold throughout their various stages. These processes are shaped by multiple actors whose interests do not always align, and have different cognitions, capabilities, and incentives. In turn, understanding these forces can help to improve our appreciation of the nature of the microfoundations of knowledge integration and its effect on the organizational outcomes.

Knowledge Integration in Individuals

Grant (1996b) proposes that organizational knowledge resides in individuals. Since different people know different things and know them differently, knowledge integration becomes a fundamental element of their learning, and is intimately connected with individuals and with their processes of memory. Examples of individual level knowledge integration that have been commonly studied include language comprehension and spatial knowledge, both of which include processes of integration of new information with existing knowledge stocks held by the individual.

A common approach to understanding individual level knowledge integration involves modelling the underlying cognitive processes (e.g., Baddeley & Hitch, 1974; Downs & Stea, 1973; Just & Carpenter, 1992; Montello, 1988; Norman & Shallice, 1980; Siegel & White, 1975), which is the approach taken in the selection-organization-integration (SOI) model (Mayer, 1996). *Selection* involves sifting through the information that becomes available from the senses, focusing on those pieces of information that are deemed relevant, and moving these pieces of information into short-term memory. This is then followed by the *organization* of pieces of information into a coherent structure that includes all of the pieces of information deemed to be most salient (Mayer, 1996; Sternberg, 1985). The final process, *integration*, involves connecting the new knowledge structure to existing organized knowledge held in long term memory. This involves the process of "selective comparison" (Sternberg, 1985) where the new knowledge is related to existing knowledge that is perceived as analogous. The result is a new knowledge structure that incorporates both new and existing knowledge into a single coherent, integrated structure.

A key implication of the SOI model we have just described is that while independent, both selection and organization are critical antecedents to knowledge integration. Factors at the individual, group, and organizational level influence either selection or organization and exert a unique influence on knowledge integration. Working memory plays a critical role in the process

at the individual level. This memory functions include the underlying sub-processes of attentional focus, attention switching between tasks, and attention division across tasks (Baddesley, 2002). Conscious attention is needed in situations where actions or behaviors are novel or poorly learned or understood, where planning is required, or where the consequences of an action are highly critical or dangerous (Norman & Shallice, 1980). Cognitive capacity serves as a limit on the extent of processing of information held in, or manipulated by, working memory, and this capacity differs between individuals. According to capacity theory, when the processing demands of a situation exceed individual capacity, both the storage and computation functions are degraded in what Just and Carpenter (1992) refer to as 'capacity constrained comprehension.'

Individual Difference in Knowledge Integration

Performance differences across individuals can be explained in terms of working memory capacity (Just & Carpenter, 1992), with the primary source of these difference resulting from variations in the executive control of attention (Baddesley, 2001; Feldman-Barrett, Tugade & Engle, 2004; Norman & Shallice, 1980). Individual capacity, ability to focus attention, processing speed, and related knowledge stocks (Bower & Hilgard, 1981) all influence the effective integration of new knowledge at the individual level.

Capacity theory also proposes that the intensity of thought required for knowledge integration varies inversely with expertise and directly with task difficulty. This is significant for understanding group and higher levels of knowledge integration. It implies that task characteristics and the individuals performing the task will exert independent effects upon knowledge integration. Task complexity, including the number of pieces of information, the diversity of knowledge domains that they represent, and their interconnections, orderings, meanings, and locations in time and space, will all raise individual's processing requirements for knowledge integration. They also

relate to the issue of group level knowledge integration as the effectiveness of group level knowledge integration is significantly determined by these individual, micro-level processes. These individual-level differences in memory capacity have not been considered in studies of group-level knowledge integration, despite the clearly critical role that individual differences play.

Shortcomings in Individual Level Research

In research exploring the microfoundations of strategic capabilities literature (e.g., Coff & Kryscyynski, 2011; Felin, Foss & Ployhart, 2015), human capital, motivations, and behaviors are the central focus in understanding organizational knowledge integration as an outcome. However, surprisingly, researchers have paid little attention to the consequences of knowledge integration and its processes for the individual members of an organization. It seems logical that participation in knowledge integration processes will have important implications for individual attitudes and behaviors. Such participation would likely widen networks internal and external to the organization. These interactions could also promote trust, which further facilitates knowledge sharing, especially of sensitive or valuable information. Moreover, active participants could learn more about their unit, company, and industry, which could enhance their competence and increase their appreciation of the value of their own work. Consequently, by participating in knowledge integration processes, employees can learn and develop new skills for the benefit of themselves and the organization. Given these shortcoming, studies would benefit from considering these individual level factors that clearly determine the efficacy of organizational knowledge integration efforts.

GROUP LEVEL PERSPECTIVES ON KNOWLEDGE INTEGRATION

While individuals may carry out knowledge integration, research highlights the group-oriented nature of knowledge integration in an organization (e.g., Qian, Agarwal & Hoetker, 2012;

Gardener, Gino & Staats, 2012). These groups could be different specialists working on new product designs and introductions, drawn from different parts of the organization (Henderson, 1994; Lam, 2000). They could also be specialized coordinators and integrators who work at the intersection of different functional areas or knowledge domains, or R&D specialists exploring new technological or scientific frontiers. Further, they could be managers working to integrate newly created ventures into a company's more established units or integrating newly launched or acquired international subsidiaries. Thus, frequently, group processes related to knowledge integration cross different organizational levels and functional activities.

Work Groups and Knowledge Integration

Work groups are important for understanding the microfoundations of knowledge integration (Minbaeva, 2013), and its development as an organizational capability. While individual characteristics may not directly influence firm level outcomes, they will often influence the performance of smaller work units or groups. For example, Gardner et al. (2012) examined group knowledge integration and found that this capability was supported by the team's experiential, relational, and structural resources, which usually reflect both individual and group level resources. Experiential resources include the knowledge, skills, and experiences that individual members of the group bring to bear on a particular task or challenge. Relational resources denote the extent of the shared experiences among group members and the consequent trust and common understanding that exists among them. Finally, structural resources indicate the dispersion or concentration of experiential and relational resources within the group.

Other research also supports the importance of relational resources. The length of time a group has worked together and the degree of cohesion among its members are usually associated with intra-group knowledge sharing (Bakker et al., 2006). Gardner et al.'s (2012) study indicates

that relational resources are more effective when widely dispersed, because of the benefit that relational resources bring across the collective. Conversely, the concentration of experiential resources is beneficial because it enhances efficiency through clarity of purpose and decision making.

In addition to having different working memory capacities, people within groups active in knowledge integration have different cognitions, goals, and strategic agendas which serve to determine the pace and quality of integration (Argote, 2012; Tripsas & Gavetti, 2000). Cognitions frame how people see, interpret, and use different pieces of knowledge, ultimately impacting their ability to undertake and join in knowledge integration successfully and expeditiously. Given differences in cognitions, reaching agreement on the meaning or value of a given piece of knowledge can be challenging. People also make inferences based on long-held assumptions, perceptions, and aspirations, which are conditioned by their personality and experiences. Their views of knowledge integration could also affect the processes involved. Political considerations surrounding knowledge integration activities, such as relative power positions or fear of loss of control, also contribute to the firm's ability to integrate knowledge. Power dynamics and rivalries within groups may inhibit knowledge sharing, leading some to withhold vital pieces of knowledge, undermining the desired outcome.

Cross-Functional Teams and Knowledge Integration

A large body of research on cross-functional teams exists (Clark & Fujimoto, 1991; Browning, 2018; Kim, 1997). Its contribution lies mainly in its explicit recognition of the need for formal planning and design of these teams in order to achieve and reap the benefits of knowledge integration (Browning, 2018). Researchers studying these issues have also addressed the organizational designs associated with the management and effective placement of these teams

within the firm's formal structure (Majchrzak, More & Faraj, 2012). They have also examined the different skills necessary to make these teams successful. While they did not discuss the processes needed to ensure effective knowledge integration, studies on cross-functional teams have enhanced our awareness of the crucial role of knowledge integration in successful innovation, discovery, and commercialization.

Researchers studying cross-functional teams have also examined the effect of physical distance on their ability to integrate knowledge and come up with innovative outcomes (Sethi, Smith, & Park, 2001). They highlight the importance of these teams' proximity to decision makers, especially the firm's senior managers. This has led companies to undertake major changes in the placement of their product and business development teams. In addition, recognizing the multilevel nature of knowledge integration, these researchers have highlighted the temporal dimension of the interactions that occur among different groups and how they affect knowledge integration (Gardner, et al., 2012). Researchers also recognized the value of knowledge integration and related processes as a source of organizational learning and the creation of knowledge (Majchrzak, et al., 2012). In fact, despite the temporary nature of some cross-functional teams (a common occurrence in today's gig economy), researchers underscore their implications for overall organizational learning and the conditions under which such learning is likely to occur, creating the momentum for strategic change, renewal, and successful organizational adaptation.

Implications of Group Level Research on Knowledge Integration

The above discussion suggests several implications for studying the microfoundations of knowledge integration and related capabilities. First, it highlights the role of work groups: knowledge-integration activities are likely to operate at the level of the group. Second, there are two group level constructs in particular which are most significant for driving knowledge

integration: relational resources and structural resources. These two sets of resources are purely group level constructs and do not exist at either the individual or the organization levels. Third, analysis at the group level does not introduce new underlying theoretical explanation as it relies upon existing social-exchange and social-psychological theories of motivation resting at an individual level of analysis. The distinction is that it introduces a mechanism for aggregation from the individual to the collective, which is the sin qua non for a microfoundational approach to explain collective level phenomena (e.g., Felin, et al., 2015).

While individuals have memory to store partial and final information sets, organizations rely upon different forms of knowledge repository systems. Knowledge repositories enable firms to accumulated knowledge based on their experiences in the past and create improved performance in the future (Argote & Guo, 2016). Two widely studied forms of organizational knowledge repository systems are transactive memory systems and routines, which we present in Table 2 and discuss below.

Insert Table 2 About Here

Transactive Memory Systems

Transactive memory contains knowledge about the memory system of another person (Lewis, 2003). It is a function of who knows what within a dyad or group. Individuals will store, encode, and retrieve information based on their assessment of whether or not that information is available from another person's memory. Retrieving that information requires interpersonal exchanges between individuals. Transactive memory, therefore, develops as a function of a person's beliefs about the information and knowledge possessed by, and accessible from, another.

While transactive memory implies that the potential memory capacity of groups exceeds that of individuals, a defining characteristic is the extent to which individual are able to access the knowledge of others in the group. While transactive memory refers to information that exists in the mind of individuals, a transactive memory system exists between individuals as a function of their individual transactive memories (Lewis, 2003; Ren & Argote, 2011; Lewis & Herndon, 2011; Wegner, Giuliano, Hertel, & Ickes 1985). Wegner states that a "transactive memory system is a set of individual memory systems in combination with the communication that takes place between individuals" (1987, P. 186). Thus, transactive memory systems are learning systems that involve knowledge integration at the group level which generates new knowledge that is useful beyond a particular group task (Lewis et al., 2005). These systems serve an analogous role in dyads and groups to that of working memory in individuals (Wegner, 1987) and have been connected with both group learning and creativity, reflecting its close connection with knowledge integration (Akgün, Byrne, Keskin & Lynn, 2006; Gino et al., 2010; Lewis et al, 2005; Ren & Argote, 2011).

Three key features effectively describe transactive memory systems: 1) individual and specialized knowledge; 2) intragroup trust and reliance concerning task level expertise of group members; and 3) task coordination among group members (Lewis, 2003; Argote & Ren, 2012). Importantly, transactive memory systems depend upon both structural and processual aspects. Structural aspects relate to who knows what, while processual aspects refer to the encoding, storage, and retrieval processes which occur between individuals (Lewis & Herndon, 2011). Over time, a dyad or group gains experience with both carrying out a given task, and with working with other members. Groups can learn about others' expertise, and build trust in their capabilities. At the same time, repeated experience provides an opportunity to develop roles and routines with

respect to knowledge sharing, and understanding who knows what and where to find needed knowledge, or where to direct new knowledge or queries.

As we note in Table 2, transactive memory systems are essential to the knowledge integration at the dyad and group level as they represent a property of the aggregate rather than any individual: “Integrations result when members discover links between members’ knowledge and create new knowledge that no member had previously possessed” (Lewis et al., 2005, p. 583-4). The transactive memory system has a cumulative quality in terms of both structure and process. The greater the depth of specialized knowledge within individuals, and the scope or range of knowledge across the individuals, the better from the perspective of identifying and filtering. Further, the greater the intragroup trust with respect to task-specific knowledge, the better the communication and coordination among group members, and the more efficiently new knowledge is routed to relevant experts within a group for its integration into the knowledge base.

The extent to which transactive memory systems are integrated versus differentiated is of significance to their potential for knowledge integration (Wegner, 1987). Systems are described as integrated when all individuals within the group or system hold the same information, and they also are aware of this common holding of information. Systems are described as differentiated where different units of information are held by different individuals, but the individuals in the group are aware of what information is held by whom. All else equal, differentiated transactive memories hold more information than integrated ones, and have a higher potential for new knowledge integration, but also require a higher level of resource investment in terms of time and energy, to coordinate productive interactions.

Therefore, transactive memory systems can explain both the process and variation in knowledge integration external to the individual. Indeed, Wegener argues that “integrative

processes are among the most important transactive events in groups" and, consequently, well-functioning groups exert a "strong directive pressure on what is to be encoded, stored, and retrieved, and places a special premium on integrative transactions" (1987, p.197).

Research on transactive memory systems. Ren and Argote (2012) argue that transactive memory in groups underlies both the core organizational processes and routines which support operations and the dynamic capabilities leading to the recombination and reconfiguration of resources and processes. This advantage is founded upon the ability to integrate and re-combine new and existing knowledge. However, the generalization of the theory of transactive memory systems from dyads and groups to organizations faces several challenges (Ren & Argote, 2011): the size of organizations increases the difficulty members face in identifying who-knows-what; multiple organized subgroups present boundaries through which knowledge must flow; and specialization within business organizations also increases the geographic dispersion that members face. These challenges, might be mitigated by technological or interpersonal solutions (Ren & Argote, 2011; Moreland, 1999).

Research has noted the value of transactive memory systems in the knowledge integration process and the subsequent performance of groups. Outcomes, such as the improved performance (i.e., faster task completion) of software (Faraj & Sproull, 2000) and consulting teams (Lewis, 2004), group learning and new product success (Akun, Byrne, Keskin, Lynn, 2006; Dayan and Basarir, 2010), and group creativity (Gino et al., 2010) have been identified. Similarly, Heavey and Simsek (2015) extend the notion of transactive memory systems to the organizational level, claiming that firms with well-developed transactive memory systems (or as they called it "a system of cognitive coordination", p. 954) benefit from improved access to information and a structure to process that information.

Transactive memory in groups is enhanced by the creation of team familiarity, specific shared experience, and training (Akgün et al., 2005; Ren & Argote, 2011). Team-skills training, focused, for example, on problem-solving, interpersonal relationships, roles, and goal setting enhances the development of transactive memory (Prichard & Ashleigh, 2007). Incentives can also impact the extent to which group members actively share responsibility for remembering similar versus different pieces of task-related information (Hollingshead, 2001) and thus support the development of integrated versus differentiated transactive memory systems.

The nature of the task can also moderate the influence of transactive memory (Moreland, Argote & Krishnan, 1996). Tasks that involve the production (i.e., the generation of new ideas), choice (e.g., among alternative courses of action), or execution of mental or physical operations, can all benefit from access to a broader range of credible expertise, which transactive memory makes possible (Lewis & Herndon, 2011). However, those tasks that are highly divisible rather than unitary, with cooperative rather than competitive or conflicting goals, or for which there are correct solutions rather than subjective judgments, will benefit the most (Lewis & Herndon, 2011; Moreland et al., 1996).

There is also a reciprocal influence of the task upon memory development, whereby transactive memory tends to develop more readily where team member tasks are divisible (i.e., encouraging division of cognitive labor), outcomes are intellective (building credibility), goals are interdependent (promoting interaction), or there is support for innovation (Lewis and Herndon, 2011; Zhang et al., 2007). Such task contexts can, for example, promote the interactions that foster the development of interpersonal trust, credible expertise, or knowledge seeking and sharing, thereby helping build transactive memory process and content.

The task environment can also moderate the effect of transactive memory on learning and adaptation. As environments become more dynamic, knowledge becomes obsolete at a greater rate, and groups must more quickly adapt to new tasks. In such settings, transactive memory in terms of specialization, trust, and coordination within a group become more important (Lewis et al., 2005; Ren et al., 2006). However, environments can exhibit stressors which either enhance or inhibit the development of transactive memory systems (Pearsall, Ellis & Stein, 2009).

Shortcomings in transactive memory research. Research on transactive memory systems has tended to focus on how they are developed and change as a result of factors such as the group's work experience (Bunderson, 2003), interdependence (Hollingshead, 2001), interactions (Hollinghead & Brandon, 2003, Pearsall, Ellis & Bell, 2009), and context (Akgun, Byrne, Keskin, Lynn & Imamoglu, 2005). However, the effect of changes in group membership (e.g., Lewis, Belliveau, Herndon, & Keller, 2007; Moreland et al., 1996) or task (e.g., Lewis et al., 2005) has been studied less frequently (Argote & Guo, 2016). Further, little research has considered how individual- or organizational-level attributes affect the development and efficacy of transactive memory systems. For example, questions about how and why individuals contribute to, or rely upon, the group's collective memory processes have not been adequately studied. Questions about how does organizational context, in terms of the firm's strategy, culture, or policies, foster or inhibit the development and effectiveness of transactive memory systems, have not been systematically analyzed. Finally, little attention has been paid to the dynamic content of these systems (i.e., how and why does forgetting, or the loss of currency or relevant knowledge, occur) or the role that transactive memory systems play in the innovation process within firms.

Routines

Understanding knowledge integrative processes in organizations requires attention to routines (see Table 2). Like transactive memory systems, routines are knowledge repositories which exist within groups and organizations, and are viewed as one manner in which organizations retain and pass memory and knowledge over time (Cyert & March, 1963). Routines are "repetitive, recognizable patterns of interdependent actions, carried out by multiple actors" (Feldman & Pentland, 2003, p. 95) which help organizations achieve consistent performance. Because of their reoccurring nature, routines can provide direction and stability to an organization (Cyert & March, 1963). Since routines guide deliberate action without the need to recreate the process each time a task is executed, they yield efficient and consistent performance and can free up cognitive resources to be used for more mindful tasks (Weick & Roberts, 1993) or other value generating activities, such as innovation (March & Simon, 1958; Ohly, Sonnentag, & Pluntke, 2006). Innovation can also result from the integration of knowledge embedded in different routines (Nelson & Winter, 1982) or through routines learned or acquired from external sources (Argote & Ingram, 2000).

Routines store organizational memory, which is further retained every time they are performed (Nelson & Winter, 1982). As such, routines are a crucial input to the skills and capabilities of organizations. When repeated and modified over time, routines can represent a source of learning and capabilities which result from the accumulation and use of prior complementary knowledge or assets in novel ways (Eisenhardt & Martin, 2000; Helfat & Peteraf, 2003; Helfat, 1997).

Research on routines. Argote and Guo (2016) observe that our views of routines have evolved over time. What once were viewed as static and certain organizational behaviors (e.g., Cyert & March, March & Simon, 1958), routines were seen by Nelson & Winter (1982) as a means

for organizations to transfer memory and knowledge over time. More recently, routines are believed to be dynamic processes (Feldman, 2000; Feldman, 2016), a perspective that places them at the center of the knowledge integration process. The dynamic nature of routines is premised on fact that they are based on two aspects: an ostensive and a performative aspect. The ostensive aspect reflects how the routine should be performed, whereas the performative aspect refers to how the routine is actually executed. Variances in the ostensive and performative aspects of routines can lead to intentional or unintentional adaptions as the performers alter the manner in which they carry out these tasks, take note of the performance implications of these variations, and make adaptions to the ostensive aspect of the routine (Feldman & Pentland, 2003). The integration of knowledge is, therefore, a fundamental piece of this process, not only in the introduction of variations, but also in how the knowledge embedded in the ostensive aspect becomes new knowledge. Further, the recombination and reordering of routines can lead to innovative variations (Kogut & Zander, 1992; Galunic & Rodan, 1998). Routines related to sensing, learning, integrating, and coordinating can also facilitate the recombination of knowledge (Pavlou & El Sawy, 2011; Dyer & Nobeoka, 2000; Bunderson & Boumgarden, 2010) as these routines provide the resources for recombination to occur. Given that routines consistent of elements of organizational knowledge, the intra- and inter-organization transfer of routines is an essential aspect to the process of knowledge sharing and integration (e.g., Rivkin, 2000; Szulakski, 1996; Zander & Kogut, 1995).

While routines themselves are intended to reduce variability and ensure consistent behavior (Cohen & Bacdayan, 1994), they can be effectively used to facilitate the integration of knowledge to create novel organizational responses. For example, in their study of new product development processes at IDEO (the global design company), Hargadon and Sutton (1997) discussed how

routines enabled the effective acquisition, storage, and retrieval and recombination of knowledge by facilitating interaction between designers and other experts. In this case, IDEO's reliance on routines led to consistent brainstorming and new product development sessions, allowing the firm to sustain performance, even in the face of group turnover. Similarly, Rao and Argote (2006), Ton and Huckman (2008) and Faraj and Xiao (2006) found that teams that used routines were able to perform better when they experienced turnover because the routine provided a key means to store and access prior group knowledge and allowed for the effective integration of new group members and the knowledge they bring. Ohly et al. (2006) found a positive relationship between routinization and creativity as the repetitive nature of work freed up the cognitive resources of employees to devote to innovation. Routines can also enable group flexibility and responsiveness as the shared understanding of the routine provides adequate structure to more easily enable the integration of improvisational or coordinated action within the group (Bigley & Roberts, 2001; Weick & Roberts, 1993).

Shortcomings in routines research. **Clearly,** our understanding of routines would benefit from a deeper exploration of how they form, evolve, or are cast aside. As routines are, by definition, interdependent actions, we know very little about how individual or group dependencies affect the process of routine development and adaptation. Similarly, while aspiration levels are often associated with the adaption of routines, we know little about how, when and why new knowledge, either intentionally or unintentionally, is integrated into organizational routines as desired variances. How do individual or group characteristics support the adoption, maintenance, or variation of organizational routines?

Although the role of groups is central to the successful execution of knowledge integration and the development of an organizational capability in this regard, the effect of these processes on

the groups involved has not been systematically studied. Knowledge integration can include two specific benefits: improved group processes and increased scope of group members' knowledge. Specifically, integration is important for group task performance as different members of a group have to share information (Robert, Dennis & Ahuja, 2008). Interactions within the groups remove barriers to knowledge sharing while improving trust that makes integration possible. These interactions could enhance solidarity among group members, giving them a stronger sense of belonging and influence. Often groups engaged in knowledge integration come from different parts of the organization; this can stretch group members' cognitive map of the firm and its operations while inducing learning.

Our preceding observations highlight the importance of groups in creating an organizational capability in knowledge integration. In turn, this also requires managing the interface between the group and the organization to address several important challenges, as we discuss next.

INDIVIDUAL AND GROUP LEVEL INTERFACE

As gleaned from our discussion of tranactive memory systems and routines, developing an organizational capability requires cultivating and managing the individual-group interface. This is because the value of individual capabilities in terms of working memory and knowledge stocks is very much constrained by its coexistence within a group, and the wider organization. The transactive memories of groups reflect the benefits of co-specialization and creates complementary assets. Thus, were individuals to leave, their performance on group-dependent tasks may be compromised, at least for a time, by lower levels of shared experience, trust, and coordination. Huckman and Pisano's (2006) study of the performance of surgeons on surgical tasks as they moved across hospitals illustrates the context dependence of individuals' capabilities. Specifically,

these authors found that a surgeon's performance at a given hospital improves significantly as the number of the surgeon's recent procedures at that hospital increases. However, experience in one hospital does not lead to improvements in other hospitals at which the same surgeon performed the same operation. Thus, performance appears to be driven by the surgeon's familiarity with the specific assets of a given hospital, including is systems and routines.

Managing the individual-group interface also means creating the right mechanisms for knowledge sharing, exchange, and interpretation. A system that enables the retrieval of group-wide experiences and accumulated knowledge is also necessary. The use of "boundary objects" to facilitate communication about the broader meaning of individuals' knowledge and expertise for group and organizational tasks is essential (Van de Ven & Zahra, 2016); individuals sometimes fail to see how their knowledge could contribute to an overall organizational capability, which they may view as abstract or far removed from their immediate responsibilities.

Clearly, micro perspectives on knowledge integrations highlighting transactive memory systems and routines have enriched our understanding of knowledge integration processes within groups and teams, explaining their macrofoundations. These discussions also show that knowledge integration processes are dynamic in nature; unfolding over space and time they make learning creativity, innovation, and adaptation possible. As such, the micro-level perspectives we discussed provide a foundation for appreciating the value of the contributions of several macro-level perspectives on knowledge integrations, as we present next.

MACRO ORGANIZATIONAL LEVEL PERSPECTIVES ON KNOWLEDGE INTEGRATION

Spender (1998) observes that while knowledge and its integration is widely discussed across several macro organizational level streams of research, each of them have its own set of assumptions and focus. This has led to fragmented findings and a lack of clarity about the nature

and role of knowledge integration as a means of value creation for the firm and its stakeholders. We identified five major macro organizational level perspectives (i.e., organizational boundaries, capabilities, knowledge management, knowledge based view, and organizational learning) which rely upon knowledge integrations processes. We discuss each of these perspectives with an eye on their collective contributions to the development of a firm level knowledge integration capability that enhances value creation. However, these streams are not mutually exclusive as research often draw across multiple streams when discussing knowledge integration.

The Organizational Boundaries Perspective

A large body of research examines questions related to organizational boundaries: What does a firm do? Which of its activities are to be performed internally vs. those which are to be conducted by external sources? Transaction cost economics (TCE), in particular, has long dominated this discussion. TCE proposes that certain organizational activities have to be conducted internally, either because of market failures or because of their strategic importance, while other activities or functions can be most efficiently outsourced (Williamson, 1979, 1981; Teece, 1986). As the conduct of certain activities are a function of tacit or immobile organizational knowledge (Nonaka & Von Krogh, 2009), knowledge plays an important role in determining where activities should be conducted, and thus answers central questions about the boundaries of the firm. The resource-based view (RBV) also suggests that knowledge can give the firm a competitive advantage rising from its rarity, inimitability, tacitness, and social embeddedness (Barney, 2001). Competitive advantage can also result from the unique value the firm derives from its application of knowledge. Consequently, there are times when the private ownership and control of knowledge are essential for determining not only the appropriate boundaries for the firm, but also for its likelihood for attaining and sustaining superior performance.

Research on organizational boundaries perspective. Researchers studying issues related to organizational boundaries have also focused on the mechanisms through which organizational resources and capabilities are obtained and leveraged for competitive advantage (e.g., Santos & Eisenhardt, 2005). This has given rise to a large body of research on the ways firms could augment or even replace their internal activities (Santos & Eisenhardt, 2005; Teece, 1986; Williamson, 1981). For example, studies have sought to explain when firms should outsource certain functions, or license the technologies and discoveries of others (Teece, 1986). This body of the literature has mushroomed further under the rubric of "open innovation," which highlights the importance of external knowledge sources in augmenting internally generated knowledge for sustaining competitive advantage, reinforcing the significance of knowledge integration as a strategic capability (Chesbrough, 2003). Similar insights can be gleaned from research on alliances and diversification (Harrison, Hitt, Hoskisson & Ireland, 2001). While most attention in this literature has focused on the organizational designs and structures that make knowledge integration possible, researchers have also underscored the value of cultivating acquisitions' or alliance partners' knowledge.

Shortcomings in boundary perspective research. A key contribution of this research steam is emphasizing knowledge as a key driver for these cross-firm boundaries (Inkpen, 1998). Firms need to develop and hone such a capability to benefit from integrating their diverse knowledge. Researchers also suggest that senior executives must ensure the development of effective organizational systems and processes to facilitate the integration of knowledge gained from external sources (Ireland, Hitt & Vaidyanath, 2002). Ironically, though usually cognizant and appreciative of the value of the integration of externally sourced knowledge, this research rarely discusses its nature, how it might best occur, who should perform it, or how it should be exploited.

These shortcomings signal an unspoken assumption that knowledge integration processes are better left to specialists in the firm, with senior executives having broad oversight. Such views may impede organizational investments and processes essential for the development of a firm-wide knowledge integration capability.

The Capabilities Perspective

Proponents of this perspective advance that firms need to have a portfolio of capabilities, keep them fresh, and deploy them effectively to gain and sustain their competitive advantage. A capability refers to a firm's ability to perform an activity or task better than its rivals. To accomplish this objective, firms must integrate their resources, particularly knowledge, to retain the currency and potency of their capabilities. Thus, knowledge integration is a central organizational activity that requires the development of a firm-wide capability that enables the churning of diverse strands of knowledge into new ideas and initiatives for use at different levels within the organization to address functional problems, develop new products, or initiate strategic change. Understandably, researchers advancing this perspective take a broad view of the types of knowledge being integrated. In particular, they note the importance of integrating external knowledge (Zahra & George, 2000a; Zahra & Nielsen, 2002), as well as the knowledge that resides in different organizational units or functions across the firm, such as marketing and manufacturing (e.g., Browning, 2018; Kim, 1997), and across different levels of the organization (Grant, 1996a).

A key contribution of the capabilities perspective is recognizing the multilevel nature of capabilities and their constituent knowledge. Knowledge from different domains, from within and outside the firm, requires integration to build capabilities. Further, this perspective also recognizes the hierarchy of capabilities that exists within a firm, where one set of capabilities undergirds higher order ones. Thus, different capabilities, operating at different organizational levels, cannot

simply be aggregated to build another set of capabilities at a different level. Rather, knowledge has to be purposefully combined, integrated, and deployed to not only develop a capability, but also to use it for strategic advantage. A related insight from this perspective is that different groups of people, operating at different organizational levels or even across levels, are involved in knowledge integration (Grant, 1996a). Hence, to build a capability (e.g., product commercialization), engineers, scientists, technologists, and marketing staff, etc. must contribute valuable insights (Keller, 2001). However, their knowledge has to be embedded in an organizational concept or a business model in order to generate a strategic advantage. Proponents of this perspective observe that middle managers, in particular, play a pivotal role in identifying new capabilities (where knowledge contributes to the development of these capabilities) and keeping them current (Hornsby, Kuratko & Zahra, 2002; Huy, 2001). Recognizing the role of middle managers and noting the need for their effective interface with senior executives, researchers acknowledge the need to understand the political, cognitive, and structural forces that influence knowledge integration in the context of capability building and organizational renewal (e.g., Raes, Heijitjes, Glunk & Roe, 2011).

Consistent with some of the micro views we presented earlier, knowledge integration can occur informally as different individuals (or groups or organizations) interact with each other (Leonard-Barton, 1992; Kahn & McDonough, 1997; Zahra & Nielsen, 2002). These interactions are important to sharing, understanding, interpreting, integrating, and using the knowledge at hand. These interactions give meaning to the knowledge being processed and integrated. Given organizations' competing needs and the multiplicity of knowledge sources within and external to them, some note the need to systemize and formalize knowledge integration activities (Iansiti, 1997; Zahra & Nielsen, 2002). As these formal activities become institutionalized and firms gain

experience in managing their knowledge integration activities, they become better positioned to develop organizational-wide capabilities that can be a major source of enduring competitive advantage.

Research on the capabilities perspective. As Table 2 suggests, researchers using this perspective highlight several outcomes for knowledge integration. These include: resource recombination (Yeoh & Roth, 1999; Verona 1999); selecting new technologies (Collinson, 2001; Inasiti & West ,1997; Helfat & Raubitschek, 2000; Henderson & Clark, 1990); enabling knowledge absorption and assimilation (Heras, 2014; Mitchell, 2006); facilitating organizational coordination to achieve efficiency, speed, agility, resilience and responsiveness (Helfat & Raubitschek, 2000); developing new products (Brown & Eisenhardt, 1995; Marsh & Stock, 2003); inducing strategic renewal activities (Yeoh & Roth, 1999); and improving organizational performance (Leonard-Barton, 1992; Henderson 1994; Zahra & Nielsen, 2002).

While the above varied contributions attest to the importance of knowledge integration, researchers seem to conceptualize the role of this construct differently. Some view knowledge integration as a predictor or antecedent of some of these outcomes, particularly performance (Brown & Eisenhardt, 1995; Collinson, 2001; Inasiti & West 1997; Pisano, 1994; Yeoh & Roth, 1999; Henderson 1994), while others (e.g., Teece et al., 1997; Verona, 1999; Yeoh and Roth, 1999) treat it as moderator. For example, Zahra and Nielsen (2002) consider knowledge integration as a moderator of the relationships between internal and external sources of manufacturing capabilities and organizational performance. In another empirical study, Zahra et al. (2000) view knowledge integration as a moderator of the relationship between new ventures' internal activities and performance. Similarly, Zahra and George (2000a) conceptualize knowledge integration as a moderator of the relationship between a firm's absorptive capacity and performance.

Shortcoming in capabilities perspective research. Overall, the capabilities perspective values the contributions of knowledge integration. Yet, studies adopting this perspective often ignore the process and activities of knowledge integration which we discussed in prior sections of this paper. Thus, within the capabilities perspective, it is not clear how or where such integration really occurs. This has led to several shortcomings in the literature. First, the literature lacks an organizing framework of knowledge integration processes, leading to the proliferation of studies that examine select variables without accounting for how these processes comprehensively build capabilities. Second, although some studies distinguish between formal and informal knowledge integration activities (Barley et al., 2018; Kim, 1997; Kodama, 1995; Zahra & Nielsen, 2002), many others overlook this distinction and fail to explore the interplay between and organizational consequences for these two facets of integration. Informal integration may complicate or facilitate formal efforts, and the effects and the conditions that influence them should be examined. Third, researchers have largely overlooked the careful study and documentation of the microfoundations of knowledge integration. This makes it difficult to appreciate how these activities unfold and how they affect the capabilities of the organization or its members. This failure makes it difficult to understand how capabilities can be meaningfully developed through intentional managerial action. Fourth, there has been a lack of attention to the dimensionality of the knowledge integration process. Whereas the literature implies such dimensionality (Huang and Newell, 2003 Sethi et al., 2001; Zahra & Nielsen, 2002), some studies apply unidimensional conceptualizations (Zahra et al., 2000). These differences in measure make it difficult to accumulate and research findings in this area. They also obscure the value of having an organization capability in knowledge integration for value creation and the conditions that might influence each of the various dimensions of the knowledge integration construct.

The Knowledge Management Perspective

Often treated independently within the field of knowledge management, the information processing, organizational cognition, attention, and knowledge based views complement each other in explaining the value of knowledge integration. The closest to the micro perspectives presented earlier, the knowledge management view examines how people, groups, and organizations use the knowledge and information they receive (Tushman & Nadler, 1978). As such, the focus is on how individuals, groups, and organizations process knowledge to make sense of it in order to find uses that create value from it. This process of sensemaking is iterative and ongoing, unfolding across knowledge domains, often crossing organizational levels and boundaries (Tell, 2017). As people process incoming knowledge, they add their own views, interpretations, understandings, and conjectures (Hansen, 1999; Mitchell, 2006), which can alter its content and how it is viewed, understood, or valued.

Research on Knowledge Management Perspective. A large body of research, indeed a field of research, exists on knowledge management in organizational settings. It suggests that the process of information processing and sensemaking often unfold across different organizational levels, adding both richness and complexity (Dougherty, 1992a, 1992b; Tell, 2017). This process is likely to shape (and be shaped by) the cognitions—the system of beliefs, values, ideologies, and perceptions—that exist among individuals and groups operating in the firm (Tripsass & Gavetti, 2000). It is also shaped by the political realities and distribution of power in firms. Power determines not only who has access to knowledge, but also influences its potential interpretations and perceived usefulness (Pfeffer, 1981). For example, powerful decision makers may discard information that challenges their beliefs, or devalues the knowledge coming from unknown sources, or presented in undesirable or unaccustomed formats. As a result, researchers have sought

to device ways to overcome these barriers to knowledge sharing and use. In particular, the attention based view (Ocasio, 1997, 2011; Ocasio & Joseph, 2018) helps to explain why managers pay attention to certain objects or pieces of knowledge, but ignore others. It further suggests that knowledge that is: 1) easy to understand; 2) proximate to recipients' knowledge base and experiences; 3) proven (has a track record of utility); and 4) from familiar and credible sources, are likely to be better perceived, considered, evaluated, and integrated with the firm's knowledge. These processes are, as noted, subject to organizational cognition. These factors can further determine the manager's willingness to share knowledge, the speed of its transfer, and the mode of its integration (Carlile, 2004; Nonaka, 1994). Effective organizational structures can help mitigate some of these issues that delay or prevent knowledge integration (Van de Ven & Zahra, 2016). Some of these aforementioned factors are analogous to those that effective the development of transaction memory systems, discussed earlier.

Shortcomings in knowledge management perspective research. Capitalizing on the intersection of information processing, cognition, and attention views enriches discussions of knowledge integration. More than any of the other macro perspectives we discuss, this intersection recognizes the social, cognitive, and political processes that unfold in organizations, and how they determine the value of knowledge and its potential integration. It also pays attention to the organizational designs needed to acquire and process incoming knowledge and how to integrate it. As such, it is the research stream that most effectively considers the micro level findings previously presented. Research using this perspective also recognizes the ongoing dialogue among cognition and knowledge integration (and vice versa), and organizational attention and knowledge integration.

Despite these contributions, to date, research attention in this area has focused on the movement of knowledge within different layers of the organization, as well as informally among organizational members without showing how, when, and where integration occurs. Thus, knowledge integration is assumed to occur automatically. Moreover, this stream of research does not speak to what happens to the integrated organizational knowledge. For example, how does it induce individual, team, or organizational learning or action? How does this knowledge influence firms' organizational memory and absorptive capacity? Finally, it does not address the strategic relevance of knowledge integration. Some of these issues are considered by researchers advocating the knowledge-based view of the firm, as we discuss next.

The Knowledge Based View

The knowledge based view (KBV) has been influential in highlighting the role of knowledge as *the* foundation of a firm's capabilities, strategies, and differential competitive positions in dynamic markets (Grant, 1996a; Kogut & Zander, 1992). Much of this research has examined ways to create knowledge and protect it from leakage and rivals' imitation (Grant, 1996a). Given the importance of knowledge for competitiveness, a firm cannot be content making good use of its existing stock of knowledge; rather, it should also keep it current, focusing on adding to it and deploying it effectively to create innovative uses and applications that create value. Consequently, KBV researchers also underscore the central role of managers in designing effective "knowledge creating organizations" by shaping their firms' culture, systems, and processes (Nonaka & Takeuchi, 1995). Nelson and Winter (1982), in particular, suggest that managers can do a great deal to develop the routines that help recombine different strands of knowledge, enabling the development and subsequent evolution of different organizational capabilities. These routines

help to revise existing capabilities or generate the dynamic capabilities that make timely and successful adaptations to changing markets possible.

Research on the KBV perspective. KBV researchers also acknowledge the structural, cognitive, and political barriers to effective knowledge sharing and use (Dougherty, 1992a, 1992b; Szulanski, 1996; Tripsas & Gavetti, 2000), as noted in Table 2. These barriers can severely hinder the integration of knowledge, the foundation of effective commercialization (Zahra et al., 2018). Some of this research also highlights the nature of organizational settings in which knowledge transfer, sharing, and integration influence organizational outcomes (Szulanski, 1996; Tell, 2017; Zahra et al., 2007, 2018). Some of these settings are challenging (e.g., highly parochial or politicized), making knowledge sharing and integration difficult, if not impossible (Szulanski, 1996; Tripsas & Gavetti, 2000).

The KBV perspective improves our understanding of the need for requisite variety in a firm's knowledge base, which typically influences its absorptive capacity (Berggren, Sydow & Tell, 2017; Cohen & Levinthal, 1990; Tell, 2017). This capacity allows the firm to recognize, value, acquire, and assimilate knowledge from outside sources, and process and transform it to create value (Cohen & Levinthal, 1990; Zahra & George, 2002). As a result, building the skills and competencies essential for sustaining the currency of absorptive capacity becomes an important managerial task, one that requires the incorporation of these activities with the firm's strategy. However, having the requisite absorptive capacity to acquire, process, and integrate knowledge is essential, but insufficient, to value creation. As noted in Table 2, firms also need to "convert" this knowledge into useful idea sets or applications (Nonaka & Von Krogh, 2009; Zahra et al. 2007). Clearly, knowledge integration is a central organizational activity, one that has important strategic implications (Grant 1996a, b; Kogut & Zander, 1992; Zahra & George, 2002a).

Shortcomings in KBV perspective research. Despite the recognition of the strategic role of knowledge integration, limited empirical research has tested the assertions of the KBV. Further, when such research is carried out, knowledge integration is not always measured directly. Rather, it is inferred from outcomes, making it difficult to determine if knowledge integration is a moderator (Van de Ven & Zahra, 2017), mediator, or even a dependent variable (Carnabucci & Operti, 2013). Existing research also ignores the processes associated with integration and where it is performed within the organization. Consequently, it is not clear from existing research how to organize for these activities or create effective systems to develop them. Further, although the importance of knowledge conversion to applications to create value is central to this view, limited attention has been given to this issue (Zahra et al., 2007). Similarly, the socio-political issues surrounding the use of integration and resulting knowledge are frequently overlooked in this research, making it difficult to explain why promising and potentially useful knowledge, such as scientific discoveries and related patents, are not always commercialized.

The Organizational Learning Perspective

Broadly, the organizational learning perspective focuses on when, how, and what organizations, as well as their units and employees, learn and to what consequence (Argote, 2012; Levitt & March, 1988; Nonaka & Takeuchi 1995). In answering these questions, researchers often employ and connect personality, cognition, and organizational processing theories to understand the different learning modes and processes occurring across different organizational levels. Given its breadth, this research has influenced various organizational sciences, including strategy, organizational behavior, entrepreneurship, and international business.

A key contribution of this research is highlighting the role of knowledge integration as an important means of organizational learning (Table 2). As companies, units, and teams (Bresman

& Zellmer-Bruhn, 2013) integrate different strands of knowledge, they can gain rich insights that form the foundation of knowledge creation. For example, as product development teams combine and integrate knowledge from across functional areas, as well as with knowledge obtained from external sources, they are able to create new knowledge that may eventually become successful products. However, knowledge integration does not stop there; organizations often learn about the fundamentals of the knowledge at hand (technical knowledge), as well as how to organize their operations to generate or use it (administrative knowledge), and the value of this knowledge for their operations, industry, and strategy. Similarly, companies that internationalize their operations often integrate local knowledge (i.e., knowledge that exists in foreign markets) with their own knowledge, frequently generating knowledge that is useful for future product development (Kogut & Zander, 1992). They also learn about foreign institutions, customers, markets, customers, and technologies in local markets (Zahra, Ireland & Hitt, 2000). Moreover, they learn how they learn (second order learning). These different facets of learning serve different organizational purposes, generating knowledge that can be potentially shared, processed, interpreted, combined, and integrated for future use.

Research on organizational learning perspective. A major pillar of the learning perspective is the continuity of the dialogue between learning and knowledge integration, forming a virtuous cycle that enables creative knowledge production and use (Table 2). Organizational learning, as noted, generates knowledge that has to be (further) integrated into the firm's knowledge base. This broadens and deepens the firm's absorptive capacity (Cohen & Levinthal, 1990), facilitating (new) knowledge acquisition, processing, and integration. This learning could be localized (i.e., in one place or related to a single issue) or dispersed (i.e., occurring at different parts of the organization or even encompassing multiple issues). Units within a firm (as well as

teams within these units) often experiment, explore, and develop knowledge. Often, however, their knowledge may be context specific and is best used to address local challenges (e.g., such as a subsidiary of a multinational company addressing immediate customer needs). In other cases, this knowledge could be useful for other applications in other parts of the organization. Such knowledge needs to be identified, articulated, transferred, shared, and integrated to be useful. Throughout these processes, the firm and its members learn new things, and learn about and from each other. These interactions improve mutual understanding, enhancing the content and usefulness of knowledge being exchanged. In turn, as noted in Table 2, this expedites and improves future knowledge integration activities and the potential use of its results.

Scholars using the organizational learning perspective recognize the multiplicity of the ways in which organizations and their units might learn (Argote & Miron-Spektor 2011; Castellaneta & Zollo 2015; Huber, 1991; Nonaka & Takeuchi, 1995). For instance, they can learn vicariously from the rivals, as well as from other companies in other industries (Kim & Miner, 2007); they can learn by doing as they carry their normal activities; they can learn by abducting others' knowledge; and learn through serendipity (Levitt & March, 1988). Companies and their units also learn by connecting to others, which are often the intended goal of strategic alliances and joint ventures. Companies may also buy equity in other companies to learn about their operations and their strategies. Moreover, a major insight from this research is the recognition that learning could occur accidentally, from organizational failures, or even crises (Argote, 2012; Nonaka & Takeuchi 1995).

A subtle point in this body of research, summarized in Table 2, is the multiplicity of the types of knowledge being generated by the firm and its units, as well as its members' use of these different modes of learning (Nonaka & Takeuchi 1995). These different types of knowledge are a

key source of strategic advantage, provided they are successfully integrated. The constant flows of new knowledge could further enrich the firm's knowledge base and its related absorptive capacity (Cohen & Levinthal, 1989, 1990; Zahra & George, 2000a). These diverse knowledge flows can also enhance companies' innovation and strategy making. They can also stimulate organizational renewal activities that improve firm performance. Clearly, the learning perspective complements the boundaries, knowledge management, and capabilities perspectives discussed earlier.

Shortcomings in organizational learning perspective research. The organizational learning perspective has generated a huge body of diverse and informative literature (Argote, 1999; Dodgson, 1993; Huber, 1991). It has been especially useful in directing managers' attention to the importance of making serious organizational investments in learning, as well as creating an environment that encourages experimentation and exploration. It has also drawn attention to learning from failure and incorporating lessons learned into organizational systems (Argote, 2012), another form of knowledge integration. Organizational learning scholars have also increased managers' awareness of the fact that much of their companies' knowledge lies within their employees. People know more than what they use at work and sometimes they are unaware of what they know and how valuable it could be. Therefore, companies need to develop the appropriate systems and incentives to capture this knowledge, preserving it for future use. Further, proponents of this approach have recognized the diverse non-financial outcomes of organizational learning, such as innovation, creating new knowledge combinations (Ahuja, Lampert & Tandon, 2008; Kogut & Zander, 1992), and ensuring adaptation. Yet, the multiplicity of views on the nature, process, and implications of organizational learning for integration is probably the reason researchers have offered different conceptualizations for its effects. For instance, some view

knowledge integration as conducive to learning, which affects organizational outcomes, such as innovation (Kogut and Zander 1992) or adaptation (Huber 1991). Thus, it serves as a predictor in this sequence. However, others suggested that knowledge integration serves a moderator between key organizational variables, such as internationalization (Zahra et al 2000), absorptive capacity (Zahra & George, 2002), and resource acquisition (Zahra & Nielsen, 2002), and organizational performance.

To summarize, when it comes to knowledge integration, the learning perspective has two serious shortcomings. The first is not articulating how organizational learning induces integration and vice versa. Thus, the mechanisms and microfundations involved are not clear, presenting an important opportunity for future research. The second is lack of clarity about "who learns" via knowledge integration versus "who applies" the resulting integrated knowledge. For example, middle managers may learn a great deal about harvesting and integrating knowledge from new acquisitions, but applying this new knowledge may be left to senior or other executives. This separation may stifle the use of newly integrated knowledge, reducing its strategic benefits to a company. Clearly, this is a major organizational design challenge, indicating another opportunity for integrating the literatures on transactive memory systems, learning, knowledge integration, and organizational design.

PROMOTING THE DIALOG BETWEEN MICRO AND MACRO PERSPECTIVES

Discussions of knowledge and its integration have moved in parallel ways in micro and macro organizational studies. This has deprived the field of systematic attention to key issues related to knowledge creation, diffusion, and subsequent use through integration. Most macro researchers seem content to assume away underlying organizational and team related processes, even though they acknowledge such processes are fundamental to knowledge integration and its

successful use. Micro researchers address these issues, but seem to assume that once knowledge is created and shared, it will be (magically) used to create value. This research also fails to address or consider the overall direction and purpose of knowledge integration, and efforts to link and develop it in a manner consistent with the firm's strategy. These are fatal assumptions that raise serious questions about the fate and utility of knowledge integration as an organizational activity. Attending to both micro and macro issues is likely to be a complicated, but essential, enterprise. We believe our review sets the stage for promoting this effective dialog by better clarifying the nature of knowledge and knowledge integration.

Knowledge Integration and Related Constructs

One of our contributions is advancing a clearer definition of knowledge integration and delineating its key dimensions (see Figure 2). This makes it possible to differentiate knowledge integration from other related concepts. Some of these dimensions have been popular in micro research; others are common in macro studies. We believe that a better recognition of the various dimension can bring us closer to capturing the theoretical domain of knowledge integration and relating its various dimensions to performance. Perhaps multi-level studies of the construct could be helpful in this regard, allowing for the better integration of micro and macro perspectives.

The various streams we have presented converge in highlighting the role of human capital as the source of this knowledge and the agent of its integration, as well as transforming and converting integrated knowledge into novel uses and applications. Moreover, while short on details about the process of knowledge integration, these streams must increasingly recognize the microfoundations of the knowledge integration process, and especially the socio-cognitive forces that surround integration.

Knowledge Integration as a Process

The micro and macro literatures discussed earlier highlight two complementary dimensions of knowledge integration. The first is its role as an *organizational process*, denoting the various steps and activities related to acquiring different types of knowledge, as well as processing, sharing, assimilating, and absorbing knowledge, which helps to convert integrated knowledge into commercial uses. This is where the concepts of routines, microfoundations, and transactive memory we introduced earlier are often used to explicate how integration is achieved. As Mitchell (2006) notes, researchers view the process of knowledge integration as involving social interactions among individuals using internal communication channels for knowledge transfers to arrive at a common perspective for problem solving. "Integrations result when members discover links between members' knowledge and create new knowledge that no member had previously possessed" (Lewis et al., 2005, p.583-4). Complementing this view, macro researchers view integration as a process of sensemaking that is governed by a multitude of forces, occurring at different organizational levels (Gardner, et al., 2012; Nonaka & Kenney, 1991), engaging individuals, teams, units, individual firms, and even networks of organizations.

However, it is not clear from the literature how firms develop their knowledge integration processes. One reason is that individuals, teams, and units that participate in knowledge integration typically have different goals, priorities, behaviors, and cognitive styles (Van Den Bosch, et al., 1999), making the process fluid and highly contextual. The structure (flow) of this process is likely to vary based on the goals pursued, the roles of different actors and their time frames, and the types of knowledge to be integrated. For example, there is a lack of uniformity in defining the various stages of knowledge integration and empirical research that identifies this sequence. This has led researchers, both micro and macro, to avoid prescribing or describing the entire process of knowledge integration and how it might unfold. Thus, an organizing framework that guides

research is lacking. This has resulted in selective attention to some obvious stages while ignoring others. For instance, there is considerable attention to issues of knowledge acquisition or sharing, but there is little or no empirical work on activities related to directing or forming connections, or on the integration processes itself. Moreover, the microfoundations of these processes have been widely ignored. Clearly, there is a need for case studies, observational, experimental, and other types of empirical work that document and identify the stages of the knowledge integration process, as well as their sequence and microfoundations, and how they shape these processes. Mid-range theory building through typology construction might also help provide some coherence in this regard. Given the diversity of activities and actors involved in knowledge integration processes, as well as the diversity of goals pursued, it may be possible to develop typologies of different knowledge integration processes or systems used at different organizational levels. These typologies could be useful in delineating the characteristics of the knowledge integration systems in use, improving our understanding of how organizations gain value from their knowledge integration efforts

Knowledge Integration as a Capability

The second dimension of knowledge integration is its role as an *organizational capability* (Weigelt, 2009), denoting a firm's competence in undertaking the various processes associated with the integration and transformation of these processes into a source of competitive advantage (Zahra et al., 2000). As such, it combines elements of cognition (e.g., the domain of that capability), skills (e.g., related companies, knowledge, and experiences), and organizational (e.g., how to do it) processes. The organizational elements require the development of routines that facilitate knowledge integration, potentially converting it into a source of the firm's competitive advantage. These routines may cover a multitude of activities, such as the identification of relevant

knowledge and their source, as well as the best way to acquire, process, and share this knowledge and develop uses for it. Each of these activities may require specific, often distinct, processes and routines to carry it out. For example, the knowledge identification function might entail developing routines for scanning the environment, conducting industry and competitive analysis, undertaking strategic intelligence, or benchmarking, etc. Some routines emerge as a result of organizational practices where managers and employees identify modifications to the ostensive components of routines to effectively accomplish a task or come up with a solution to an organizational problem. Other routines are formally designed and engineered to perform a particular task. The infusion of new knowledge keeps these routines current and focused. For example, feedback on how well the performative aspect of routines work could generate insights into how to improve them. Incorporating best practices can also renew routines and keep them fresh and useful. The point to remember is that companies need to develop these routines and integrate them into a coherent organizational capability that, in turn, enables them to systematically integrate diverse knowledge and convert it into useful commercial applications, giving the firm a source of competitive advantage.

Macro researchers recognize the importance of routines and the microfoundations of the knowledge integration capability (Nelson & Winter, 1982; Winter, 2003). Yet, surprisingly, they pay little attention to integrating these notions in their theorizing or empirical testing; they appear to assume that these underlying routines and microfoundations happen naturally or automatically. Given that routines are the nucleus of the (organizational) knowledge integration capability, there is a need to better understand when, how, and why certain routines are selected and integrated (Cohen & Bacdayan, 1994). Similarly, given the evidence for drivers and inhibitors of knowledge integration at the individual and group level, we need to integrate such micro level factors into

explanations of organizational level capabilities. We cannot understate the value of this observation given that developing such a basic understanding can help clarify how organizational processes enable the formation of that routine or capability. Further, because formal and informal processes often contribute to the development of an organizational level knowledge capability, we cannot assume that having a formal knowledge integration process automatically leads to an organizational capability. In fact, several factors influence the emergence and evolution of a capability. These forces can occur at the individual (e.g., attention and cognitive efficiency), group (e.g., transactive memory), and the organizational (e.g., senior executives' vision and resource commitments) levels. Over time, the interaction of these forces can shape the emergence and subsequent evolution of a knowledge integration capability that gives the firm a competitive advantage. Consequently, effective organizational design is essential for building this capability and making it strategically relevant by, for example, gaining the attention and support of senior managers and other users of integrated knowledge. Clearly, research that connects and integrates the micro and macro perspectives we discussed earlier can enrich our understanding of the potential strategic benefits that can accrue from knowledge integration and where (and when) they materialize.

Formality of Knowledge Integration Systems

The micro- and macro- perspectives just discussed do not address the nature of the organizational processes involved in knowledge integration. Micro researchers appear to focus on informal processes, whereas macro researchers appear to assume that these processes happen automatically. As a result, the literature suggests that companies are likely to vary in the extent to which they formalize their knowledge integration activities, and that formalization somehow assures successful integration. The firm's primary industry is an important source of this variation

(Ahuja, 2000; Cohen & Levinthal, 1990). Some industries ensure rich and varied knowledge spillovers that could benefit recipient firms, highlighting the need for integration. Moreover, when the rate of change in an industry's knowledge base is high (as happens at times of technological shifts), the need for knowledge integration rises. Industry social structures (i.e., how companies interact and relate to each other; Greve, 2005) also influence joint knowledge creation, as well as subsequent sharing and integration (Ahuja, 2000). The strategic importance of knowledge as a source of value creation also varies across industries, affecting companies' incentives to undertake knowledge integration processes.

Firm-related factors are also likely to affect the need for formal knowledge integration processes. For example, the diversification of a firm's knowledge base due to its R&D, alliances, and commercialization processes, the diversity of its technological base, as well as the diversification of its markets and products, often make formal knowledge integration essential. In these cases, the firm receives different types of knowledge from multiple (and sometimes incompatible) sources. Further, given that companies (especially diversified ones) depend on multiple sources (e.g., different customers and suppliers) of knowledge to succeed, these dependencies increase their need for formal knowledge integration.

The characteristics of knowledge itself also encourage formal knowledge integration. For example, when new knowledge is hard to understand, it must be translated for others within the firm. Similarly, when the volume of incoming knowledge is high, the need for formal integration is greater. Finally, when knowledge is complex, consisting of multiple intricately linked elements or crossing different knowledge domains, the need for formal knowledge integration is high. This is one area of research where the integration of micro and macro perspectives could add richness to future research, especially in terms of identifying potential microfoundations.

Stages of Knowledge Integration

Our discussion suggests another important question that has been overlooked in prior micro and macro discussions of knowledge integration. What should a knowledge integration system embody? In other words, what are the different processes involved? Integrating the diverse perspectives discussed earlier, we identify five stages. The first is *knowledge development and acquisition*, where firms use their connections, relationships, and systems to gain access to and assemble the knowledge (Inkpen & Tsang, 2005). The second is *knowledge valuation*. Cohen and Levinthal (1990) observe that companies usually have access to vast amounts of knowledge from internal development and external sources (e.g., open innovation sources, alliances, or other network relationships). Therefore, a firm must develop the capacity to identify potentially useful knowledge that requires integration (Helfat & Campo-Rembado, 2016; Zahra & George, 2002a). The third stage is *knowledge transfer, exchange, and sharing*, which focuses on the identification of relevant knowledge to be acquired, the actual importation of the relevant knowledge (Mitchell, 2006), and its transfer from its source to the acquiring firm (or within the firm). This is a challenging process because of the multiplicity of organizational, structural, cognitive, behavioural, and political barriers (Alavi & Leidner, 2001; Argote, 2012; Argote, McEvily & Reagans, 2003). The fourth stage is *making connections* through the creative synthesis of various types of knowledge (Andreu & Seiber, 2005; Mitchell, 2006). The fifth and final stage is *knowledge deployment*, where the focus is on targeting different combinations of knowledge for particular uses (Mitchell, 2006).

While logical, the five stages just presented are not exhaustive and need to be empirically validated to determine their existence, the extent of their use, and their overall contribution to developing an effective sets of processes that lead to a sustainable organizational knowledge

integration capability. Further, we need to determine the sequence of these activities and where (and how) they are carried out. Given that knowledge integration unfolds in a dynamic socio-cognitive context, laden with political maneuvering and intrigue because of the diversity of actors and their goals, understating these processes could offer important insights into the mechanisms that explain why some organizations are able to enjoy greater benefits from their knowledge integration activities. These mechanisms have been rarely articulated by micro and macro researchers.

Micro researchers have been attentive to the role socio-cognitive and political forces can play in determining the speed and quality of knowledge integration, affecting its outcomes, such as the timing of market entry or pioneering in a given technology. Macro researchers have tended to ignore this role, leaving much to answer about the contributions of knowledge integration to value creation. In contrast, while macro researchers have been more careful to relate integration to firm level outcomes, their micro counterparts have been less systematic in this regard. Clearly, both research camps could learn from each other, improving the contributions of their findings. Macro scholars need to consider processes, context, and system characteristics; micro scholars need to be more deliberate in linking their processes to organizational value creation activities.

Measuring Knowledge Integration

As our discussion indicates, knowledge integration has implications for individuals (e.g., learning and discovery), team (e.g., innovation and task accomplishments) and firms (e.g., adaptation, learning, and performance). Micro and macro research has lacked systematic attention to documenting these effects. Therefore, micro and macro scholars would benefit from carefully measuring knowledge integration. Prior efforts to measure or empirically capture the construct have been also diverse and inconsistent, making generalizations problematic. For example, the

dimensionality of the construct remains contested as some view it as a unidimensional construct (e.g., Lorenzoni & Liparini, 1999, Zahra et al., 2000), while others treat it as multidimensional (e.g., Pisano, 1994; Verona, 1999; Helfat & Raubitschek, 2000). Further, measures have been diverse and except for a few notable studies (e.g., Weigelt, 2009, who used Steensma and Corley's (2000) measure; Dangelico, Pontrandolfo & Pujari (2013), who based their items on Laursen and Salter (2006)); almost every empirical study has used a unique measure (and the majority of these studies did not provide evidence of reliability or validity). Further, at the level of microfoundations, the measures more typically focus upon knowledge exchange between individuals and groups, as opposed to organizational level knowledge integration (e.g., Grigoriou & Rothermael, 2014; Minbaeva et al., 2012). These issues raise serious concerns about prior findings and their external validity; they also indicate a need for more carefully crafted research. Finally, while qualitative work (e.g., Henderson & Clark, 1990; Henderson, 1994; Iansiti & West, 1997) initially dominated studies of knowledge integration, more recent scholars have used empirical measures based on archival or secondary data (e.g., Xu, Wu & Cavusgil, 2013; Alcalde Heras 2014; Liu & Ravichandran, 2015) or surveys (e.g., Nambisan, 2013; Zahra et al., 2000). This development opens the door for constructive replications that enhance confidence in the generalizability of findings. Researchers should also be more transparent and clearly express what they are really measuring. This review has noted the multi-facted nature of knowledge integration, and has highlighted its defining components, dimensions, and stages. We encourage future researchers to consider these and other relevant aspects of the knowledge integration process and discuss what their measures of knowledge integration truly capture.

Considering the Nomological Network of Knowledge Integration

A final issue for micro and macro scholars to consider is the role of knowledge integration, whether a process or capability, in a nomological network. Prior efforts have represented knowledge integration differently in their models, both as an antecedent and outcome. For example, in the emerging microfoundations of strategic capabilities literature (e.g., Coff & Kryscyynski, 2011; Felin, Foss & Ployhart, 2015), human capital, motivations, and behaviors are the central focus in understanding organizational knowledge integration as an outcome. Still, others have viewed knowledge integration as a mediating (e.g., Henderson, 1994) or moderating variable with respect to organizational outcomes (e.g. Alcalde Heras, 2014; Zahra et al., 2000; Zahra & George, 2002a). These different perspectives mean that there is little clarity on how knowledge integration fits within its nomological network. This lack of precision leaves many important questions unanswered, including whether or not knowledge integration is procedural or cultural, whether or how it can be managed at either a macro or micro level, and when or how knowledge integration is particularly influential in improving organizational outcomes. Understanding this nomological network, in turn, requires greater attention to factors that could moderate the relationship between knowledge integration and organizational outcomes. Examples include the firm's entrepreneurial orientation (Foss et al., 2013), its absorptive capacity (Zahra & George, 2002a), and the adaptiveness and flexibility of the organizational structure (Cohen & Levinthal, 1990). This lack of understand seriously degrades the value of knowledge integration as an organizational concept.

CONCLUSION

The concept of knowledge integration is widely used throughout management and organizational studies. However, the popularity and common use of the construct betrays an absence of attention to its domain, dimensions, and outcomes. We have reviewed, analyzed and

integrated a vast body of micro and macro level studies seeking to bring about greater clarity regarding the contributions of diverse theoretical perspectives to understanding knowledge integration and its usefulness, especially in organizational setting where a premium is placed on creating value. Our analysis and review not only highlights the importance of knowledge integration, but also underscores the importance of integrating micro and macro level perspectives to enrich our understanding of the concept and advance research aiming to make it even more useful for companies and their managers.

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Table 1

Definitions of Knowledge Integration

Nonaka & Kenney (1991)	"The ability of personnel to create new meanings" (p. 80)
Iansiti & West (1997)	“Technology integration is the approach that companies use to choose and refine technologies employed in a new product, process, or service” (p. 69)
Verona (1999)	Integrative capability “acts as an adhesive by absorbing critical knowledge from external sources and by blending the different technical competencies developed in various company departments” (p. 134)
Yeoh & Roth (1999)	“Integrative capabilities refer to the ability of a firm to use resources and component capabilities to support organizational renewal. Integrative capabilities reflect the ability to deploy or use both resources and component capabilities in new or flexible ways to support organizational renewal.” (p. 640) Also note: “The integrative capability dimension is similar to the notions of ‘combinative capabilities’ (Kogut and Zander, 1992) and ‘architectural competence’ (Henderson and Cockburn, 1994).” (p. 641)
Helfat & Raubitschek (2000)	“we define *integrative knowledge* as: knowledge that integrates, or knowledge of how to integrate, different activities, capabilities, and products in one or more vertical chains. (p. 964)
Collinson (2001)	Knowledge integration "the process of combining [specialist knowledge from technical specialists, customers, competitors, and collaborators] to solve the various problems facing decision makers at all levels of the firm." (p. 336)
Lorenzoni & Liparini (1999)	"In order to manage efficiently the complex relational sets in which they are embedded, organizations must develop: the ability to absorb competencies from others (Cohen and Levinthal, 1990); the ability to combine and coordinate the technical dimensions of a large number of firms (Kogut and Zander, 1992)
Marsh & Stock (2003)	Intertemporal integration (IC) is defined as “the process of collecting, interpreting, and internalizing technological and marketing capabilities from past new product development projects and incorporating that knowledge in a systematic and purposeful manner into the development of future new products.” (p. 136)
Henderson & Cockburn (1994)	“The 'architectural competence' of an organization allows it to make use of its component competencies: to integrate them together in new and flexible ways and to develop new architectural and component competencies as they are required.” (p. 66)
Woiceshyn & Daellenbach (2005)	“This capability to integrate knowledge from sources both external and internal to the firm and utilize it productively has been called, for example, architectural competence (Henderson and Cockburn, 1994), combinative capability (Kogut and Zander, 1992), dynamic capability (Teece *et al*., 1997), integrative

	capability (Lawrence and Lorsch, 1967; Henderson, 1994; Iansiti and Clark, 1994), knowledge management capabilities (Collinson, 2001) and organizational architecture (Nelson, 1991). Given the focus here on external and internal integration as two of the sub-processes of technology adoption, we use the term 'the integrative capability of the firm'." (p. 310)
Kogut & Zander (1992)	Higher order organizing principles which "act as mechanisms by which to codify technologies into a language accessible to a wider circle of individuals. These principles establish how the innovation is transferred to other groups, the responsibility of engineers to respond to complaints, and the allocation of incentives to establish authority over decisions. These organizing principles, which we call higher-order as they facilitate the integration of the entire organization, are also supported by data regarding profitability, costs, or task responsibility (as represented in an organizational chart)." (pp. 389-390) "By combinative capabilities, we mean the intersection of the capability of the firm to exploit its knowledge and the unexplored potential of the technology, or what Scherer (1965) originally called the degree of "technological opportunity." (p. 391)
Grant (1996a)	"the primary role of the firm, and the essence of organizational capability, is the integration of knowledge." (p. 375)
Grant (1996b)	"The assumptions that there are gains from specialization in knowledge acquisition and storage, and that production requires the input of a wide range of specialized knowledge, restates a premise which, either explicitly or implicitly, is fundamental to all theories of the firm. Without benefits from specialization there is no need for organizations comprising multiple individuals. Given the efficiency gains of specialization, the fundamental task of organization is to coordinate the efforts of many specialists. Although widely addressed, organization theory lacks a rigorous integrated, well-developed and widely agreed theory of coordination." (p. 113)
Qian, Agarwal, Hoetker (2012)	"integrative capabilities, which Helfat and Raubitschek (2000) defined as knowledge of how to integrate activities, capabilities, and products in one or more vertical chains." (p. 1332)
Dangelico, Pontrandolfo & Pujari (2013)	"when firms do not have the resources and competencies to innovate on their own, they rely on external integrative capabilities. These capabilities, such as creation of collaborative networks, allow the firm to access external sources and act as adhesive absorbing critical knowledge and resources (Cohen and Levinthal, 1990)." (p. 645)
Gardner et al., 2012	Knowledge integration capability is "reliable patterns of team communication that generates joint contributions to the understand of complex problems" (p. 999)
Lin, Su & Higgins (2016)	to the ability of relocating, recombining and reusing both existing resources and those obtained, for example, resource relocation and reconfiguration capability, and knowledge-integration capability.
Mitchell (2006)	An ability to integrate knowledge within and across organizational boundaries (Henderson, 1994).

Weigelt (2009)	A firm's capacity to use and assimilate a new technology with its business processes and build upon it (p. 595)
Alcalde Heras (2014)	Knowledge integration dictates the firm's ability to absorb new knowledge and determine the type of innovation search strategy (explorative or exploitative), which in turn defines the available stock of technological sources. (p. 385)
Xu, Wu & Cavusgil (2013)	The ability of firms to identify, acquire and integrate valuable knowledge within and across firm boundaries (pp. 750-51)
Singh (2008)	Cross-regional integration – formal and informal intra-firm mechanisms designed to make the dispersed knowledge available throughout the firm (pp. 77-78)
Tiwana (2008)	The process of jointly applying specialized knowledge held by various alliance partners at the project level. (p. 255)
Boh, Ren, Kiesler & Bussjaeger (2007)	How organizations combine the expertise of individual employees and deploys people in teams.
Zhou & Li (2012)	Dissemination and synthesis of individually and organizationally held knowledge through established processes and routines. (pp. 1091-1092)
Frishammer, et al., (2012)	knowledge integration is viewed as an ongoing collective process of constructing, articulating, and redefining shared beliefs and expertise through social interaction among organizational participants (P. 575)
Nambisan (2013)	We define knowledge integration mechanisms (KIM) as the set of structural arrangements and processes that firms employ to diffuse, analyze, interpret, and combine knowledge within the firm. This includes the use of formal reports and memos that summarize learnings, information-sharing meetings, formal project reviews, and cross-functional teams. (p. 931)
Kraaijenbrink (2012)	knowledge integration - developing and coordinating a cohesive organizational knowledge base (p. 1084)
Helfat & Campo-Rambado (2016)	consists of routines for communication and coordination that rest on common codes of communication, which in turn reflect shared understanding and common knowledge. (p. 253)
Kamuriwo & Baden-Fuller (2016)	facilitating dense knowledge flows and cross domain linkages that aid innovation and knowledge building and also aid in sensing, absorbing and integrating external knowledge (p. 1039)
Deluca & Atuahene-Gima (2007)	The formal processes and structures that ensure capture, analysis, interpretation and integration of market and other types of knowledge among different functional units within the firm (p. 95).

Deluca, Verona & Vicari (2010)	formal mechanisms—such as formal information exchange meetings, projects committees, use of internal experts and consultants, and formal project reviews— that ensure the capture, analysis, interpretation, and integration of different types of knowledge (i.e., scientific and marketing) within the firm. (p. 300)
Frost & Zhou 2016	As the utilization by one multinational subunit of knowledge originating in another.
Robert, Dennis & Ahuja (2008)	the "synthesis" of individual team members' information and expertise through "social interactions." (p. 315)
Majchrzak, Wagner & Yates (2013)	the recombination of knowledge by merging, categorizing, reclassifying, and synthesizing existing knowledge (p. 456)
Cheung, Myers & Mantzer 2011	occurs when organizations develop relationship-specific memories whereby knowledge specific to that relationship is stored in organizations' collective cognitions, beliefs, and values, and idiosyncratic routines are developed in the form of encoded formal and informal procedures for how the parties interact. (p. 1067)

TABLE 2

Micro and Macro Organizational Perspectives on Knowledge Integration

Perspective	Key Propositions	Outcomes	Role of Knowledge Integration	Key Shortcomings
Individual Level Knowledge	Organizational knowledge resides in individuals Grant (1996b). Knowledge integration is a fundamental element of their learning, and is intimately connected with individuals and with their processes of memory. Individual level knowledge integration is a cognitive process, (e.g., Baddeley & Hitch, 1974; Downs & Stea, 1973; Just & Carpenter, 1992; Montello, 1988; Norman & Shallice, 1980; Siegel & White, 1975), frequently represented by the selection-organization-integration (SOI) model (Mayer, 1996). Selection involves sifting through information to focus on the most relevant, and moving it into short-term memory. Organization moves these pieces into a coherent knowledge structure (Mayer, 1996; Sternberg, 1985). Integration, involves connecting the new knowledge structure to existing knowledge held in long term memory. Individual performance can be explained by working memory capacity (Just & Carpenter, 1992). Attention, expertise, information diversity and complexity, and task difficulty all effect the integration process.	New knowledge held by the individual (Just & Carpenter, 1992; Baddesley, 2001; Feldman-Barret, Tugade & Engle, 2004).	Helps the individual build their working memory capacity.	Researchers have paid little attention to human capital, motivations, and behaviors on the consequences of knowledge integration. What impacts do knowledge integration efforts conducted at the organizational level have on individuals and their behaviors?

Transactive Memory Systems	Transactive memory systems exist between individuals as a function of their individual transactive memories (Lewis, 2003; Ren & Argote, 2011; Lewis & Herndon, 2011; Wegner, Giuliano & Hertel, 1985). As such, they are learning systems that involve knowledge integration at the group level which generates new knowledge that is useful beyond a particular group task (Lewis et al., 2005). Transactive memory systems rely upon individual and specialized knowledge, intragroup trust and reliance concerning task level expertise of group members, and task coordination among group members (Lewis, 2003). They depend upon both structural (which relates to who knows what – where knowledge is stored across the group or system) and processual aspects (which refer to the encoding, storage, and retrieval processes which occur between individuals) (Lewis & Herndon, 2011). Transactive memory occurs only at the level of the dyad or group and is fundamentally dependent upon interaction and is analogous to working memory in individuals (Wegner, 1987). The transactive memory system, therefore, can explain both the process and variation in knowledge integration external to the individual and affirms the reason for a group's existence as and is the source of new knowledge creation in groups and organizations.	Group performance Austin, 2003; Faraj & Sproull, 2000, Liang wt al, 1995; Moreland et al., 1996; Rulke & Rau, 2000; Michinov & Michinov, 2009. Group learning and new product success Akgun et al., 2005. Group reflexivity and product success Dayan & Basarir, 2010. Group creativity Gino et al., 2010.	An outcome of underlying organizational processes.	Research has tended to ignore how individual (e.g., motivation) and organizational-level attributes (e.g., culture and HR practices) contribute to transactive memory systems. Dynamic nature of transactive memory systems (e.g., forgetting, loss of currency or relevance of knowledge, turnover) has received little attention. How and when transitive memory systems contribute to innovation is not well understood.

Routines	Routines are "repetitive, recognizable patterns of interdependent actions, carried out by multiple actors" (Feldman & Pentland, 2003, p. 95) which help organizations achieve consistent performance. Routines can lead to the development of new skills and provide the basis for knowledge integration as firms learn by doing (Eisenhardt & Martin, 2000; Helfat and Peteraf, 2003). Routines can also represent a source of dynamic capabilities which result from the accumulation and use of prior complementary knowledge or assets (Helfat, 1997). Routines are dynamic processes. Variances in the ostensive and performative aspects can lead adaptions as the performers vary the manner in which they carry out their routines, and make adaptions to the ostensive aspect of the routine (Feldman & Pentland, 2003). The integration of knowledge is fundamental not only in the introduction of variations, but also as the ostensive aspect of the routine becomes new knowledge for the organization.	Sources of variation Nelson & Winter, 2002; Pentland et al., 2012; Turner & Fern, 2012. Knowledge recombination Kogut & Zander, 1992; Yi et al, 2016; Galunic & Rodan, 1998; Bunderson & Boumgarden, 2010. Innovation Cyert & March, 1963; Ohly et al., 2006.	An outcome of underlying organizational processes.	Processes by which routines become dynamic and enable variation are not well understood. Little is known about how interdependencies are associated with positive aspects of routines (e.g., sources of variation, innovation). How, when and why does new knowledge become integrated into new routines? How do group or individual characteristics effect the formation and adaption of routines.
Boundaries	The need for and nature of organizational knowledge determines the extent to which firms internalize their operations (Grant, 1996 a, b; Liebeskind, 1996) Knowledge acquisition and subsequent integration is a key determinant for external sourcing (Chesbrough, 2003; Kogut & Zander 1992; Teece, 1986; Zahra & Nielsen, 2002)	Organizational efficiency Teece, 1986. Capability building Grant, 1996b. Innovation Chesbrough, 2003. Competitive advantage Kogut & Zander, 1992.	Moderator (Grant, 1996b; Liebeskind, 1996)	Does not directly measure knowledge integration. Ignores underlying processes and microfoundations. Does not document how integrated knowledge is used to achieve purported outcomes.

Capabilities	Views knowledge integration as an organizational capability that combining of knowledge from different domains (Yeoh & Roth, 1999). A special focus on integrating external knowledge with the firm's own knowledge while recognizing knowledge integration activities across units (Gupta et al., 1986; Verona, 1999) as well as organizational levels and boundaries (Henderson, 1994; Mitchell, 2006). Knowledge integration occurs informally or formally (Zahra & Nielsen, 2002). However, there is consensus that formal integration is necessary to derive desired organizational benefits.	Selecting technologies Collinson, 2001; Inasiti & West ,1997; Helfat & Raubitschek, 2000; Henderson & Clark, 1990. Resource Recombination Yeoh & Roth, 1999; Verona 1999. Organizational coordination Helfat & Raubitschek, 2000. Knowledge assimilation Heras, 2014; Mitchell, 2006. Competence development Henderson & Cockburn, 1994. Product development Brown & Eisenhardt, 1995; Marsh & Stock, 2003. Learning Iansiti, 1997; Zahra et al., 2000. Renewal Yeoh & Roth, 1999. Performance Leonard-Barton, 1992; Henderson 1994; Zahra & Nielsen, 2002.	Predictor (Brown & Eisenhardt, 1995; Collinson, 2001; Inasiti & West 1997; Pisano, 1994; Yeoh & Roth, 1999; Henderson 1994) Mediator (Teece et al., 1997 Verona, 1999, Yeoh & Roth, 1999) Moderator (Zahra et al., 2000, Zahra & George, 2002a; Zahra & Nielsen, 2002)	How to develop or transform knowledge into an organizational capability is ignored. Integration processes are ignored and micro foundations overlooked. Lack of attention to dimensionality of the construct.
Knowledge Management	Organizations vary significantly in their knowledge processing capabilities (Tushman & Nadler, 1978). Information processing is subject to political, organizational (structural), cognitive and	Learning Anderson & Lewis, 2014. Knowledge creation Nonaka & Takeuchi, 1995.	Moderator (van de Ven & Zahra, 2017)	Ignores processes of integration and who is responsible for them. Thus, it is not clear how to organize for these activities or develop

	political (power) factors (Dougherty, 1992a,b; Carlile, 2004; Nonaka, 1994). Information processing combines with cognitive forces to generate new interpretations and meaning to knowledge (Hansen, 2002; Mitchell, 2006). Knowledge integration seeks to combine different strands of knowledge derived from different domains, often crossing boundaries, to create new recombination (Dougherty, 1992a, b; Grant, 1996 a, b; Kogut & Zander, 1992, Zander and Kogut, 1995; Piasno, 1994). These boundaries involve: individual, domain specific, task specific, spatial, temporal dimensions (Tell, 2017) Executives pay differential attention to particular types of knowledge and these become more strategically useful and actionable (Ocasio, 1997, 2011; Ocasio & Joseph, 2018). To succeed in integrating its knowledge, the firms must have the requisite absorptive capacity (Berggren, Sydow & Tell, 2017; Zahra & George, 2002) To be strategically valuable, firms need to "convert" integrated knowledge into applications (Nonaka & Von Krogh, 2009; Zahra et al., 2007). This requires not only knowledge sharing, exchange and translation but also accurate valuation of knowledge (Helfat & Camo-Rembado, 2016; Zahra & George, 2002a).	Strategic initiatives Zahra et al., 2007. Innovation novelty Van de Van & Zahra, 2017. Team performance Robert, Dennis & Ahuja, 2008. Organizational Performance Pisano, 1994; Zahra et al., 2007.		effective systems to develop them. Limited attention is given to knowledge conversion to strategic and other application (Zahra et al., 2007). Socio-political issues regarding the use of knowledge integrated are overlooked, making it difficult to explain while many promising and potentially useful knowledge such as scientific discoveries and related patents are not commercialized (Zahra et al., 2017). Knowledge integration is not always measured; rather it is inferred from outcomes.

	There are different modes for knowledge integration (Boer et al., 1999; Collins and Smith, 2006; Jansen et al., 2005).			
Knowledge Based View (KBV)	Knowledge integration is an essential organization function/ capability (Kogut & Zander, 1992). Integrated knowledge is a key sources of value creating activities (Kogut & Zander, 1992). Value creation results from converting newly integrated knowledge into unique application and uses (Zahra et al., 2012) To create value, knowledge integration should be connected to the firm's strategic direction and focus (Grant, 1996a).	Capability building Kogut & Zander, 1995 Performance Grant, 1996a, Kogut & Zander, 1992. Innovation and novelty Zahra et al., 2012. Team and organizational level learning Tripsass & Gavetti, 2000.	Rarely discussed even though theoretical and conceptual development suggest a role as potential moderator (Kogut & Zander, 1992, 1995)	Assumes an automatic process that leads to integration, ignoring its microfoundations Does not address the processes of integration or how newly integrated knowledge is converted into unique application. Ignores organizational and political distance between those who integrate knowledge and those who use it. Little empirical testing of key assertions and propositions
Organizational Learning	Knowledge integration induces organizational learning (Nonaka & Takeuchi 1995). This learning improves organizational memory and builds absorptive capacity that enables the acquisition and processing of new knowledge that has to be integrated to create value (Cohen & Levinthal, 1989,1990; Dougherty, 1995). Knowledge created within the firm through integration could be localized; it has to be transferred or diffused throughout the organization to create value. This diffusion creates momentum for integration that (also)	Learning in new markets Zahra et al., 2000. Learning new technologies Iansiti, 1997. Changing organizational culture Nonaka & Takeuchi 1995. Innovation Kogut & Zander, 1992. Addressing crises Argote, 2012. Performance	Predictor (Huber, 1991; Kogut & Zander; 1992; Nonaka & Takeuchi, 1995) Moderator (Zahra et al., 2000; Zahra & George, 2002a; Zahra & Nielsen, 2002)	Lack of clarity about the mechanisms or conditions that induce learning through knowledge integration. Separation of who carries out knowledge integration and knowledge uses, creating a valley of death where potentially valuable knowledge goes unused.

	promotes learning (Dougherty, 1992a, b; Nonaka & Takeuchi 1995). Knowledge integration has a multitude of non-finacial outcomes such as creating new knowledge recombinations (Ahuja, Lampert & Tandon, 2008; Kogut & Zander, 1992). Similar to learning, knowledge integration could occur formally and informally (Nonaka & Takeuchi, 1995; Zahra & Nielsen, 2002). These activities need to be integrated to improve organizational processes and outcomes. Organizational design issues affect the outcomes of knowledge integration.	Dodgson, 1993; Huber 1991; Zahra et al., 2000.		

Figure 1

A Distillation of the Definitions of Knowledge Integration

What is it?	Who does it?	What is done?	What is integrated?	What are the sources?	What are the outcomes?
How is the operation or action of knowledge integration described?	*Who are the parties engaged in knowledge integration?*	*What are the mechanics of knowledge integration? How is information used and altered?*	*What forms do the pieces of information take? What is the raw material of knowledge integration?*	*Where do the pieces of information originate or come from in knowledge integration?*	*What is developed or created as a result of knowledge integration?*
e.g., ability; adhesive; approach; capability; capacity; dimension; knowledge; mechanism; process; reliable pattern; routines; structures; task	e.g., company decision makers firm organization personnel individuals project committees teams	e.g., absorb; acquire; blend; build upon; capture, codify; combine; coordinate; creation; develop; disseminate; incorporate; integrate; jointly apply; make use; merging; recombination; refine; reusing; synthesizing	e.g., activities, capabilities, collective cognitions, beliefs, and values; component competencies; dense knowledge flows and cross domain linkages; expertise; knowledge base; shared understandings; technical competencies; market capabilities	e.g., alliance partners; collaborative networks; departments; functional units; experts; consultants; external sources; firms; employees; past new product development projects; team members; vertical chain	e.g., exploitative/ explorative strategies; knowledge; innovation; architectural/component competencies; new meanings, products, process, or services; organizational renewal